

Development of a Highly Durable IrO₂-based Anode to Cathodizing-induced Deterioration

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An insoluble oxygen evolution anode consisting of an IrO₂-Ta₂O₅ catalytic layer formed on a titanium substrate has been increasingly used in electroplating industries such as electrogalvanizing and electroplating of steels. The excellent catalytic properties and long lifetime have been recently proven in such a commercial use.^{1,2}

However, there are some cases wherein the rapid consumption of the IrO₂-Ta₂O₅ coating occurs partially in commercial electrogalvanizing lines (EGLs). Such an anomalous deterioration of the coating is observed on the anode located outside of the width of a steel strip when the steel strip moves between two anodes and both the strip surfaces are electrogalvanized.³ This undesirable phenomenon is often accompanied by the deposition of zinc on the anode. Based on these results, we considered that the anomalous degradation of the IrO₂-Ta₂O₅ coating was possibly caused by the partial cathodic polarization of the anode, and we called this the "cathodizing of the anode" at the particular part.

The possibility of the cathodizing of the anode was examined based on numerical calculations of the primary potential and current distributions in the electroplating cell simulating the actual one in EGLs⁴. When there exists a potential difference between two anodes located parallel to both surfaces of a steel strip, the cathodizing of the anode could occur on the anode having lower potential at the particular part outside of the width of the steel strip. We also investigated the effects of cathodizing on the durability of IrO₂-Ta₂O₅/Ti electrodes during electrolysis with periodically reversed (PR) current in sulfuric acid solutions.^{3,5} The results indicated that the lifetime of the electrode was drastically shortened by the PR electrolysis compared to that in continuous anodic electrolysis. It was also found that the surface morphology of the electrode after the PR electrolysis was analogous to that of the anode rapidly deteriorated in commercial EGLs. Our previous study further revealed that the rapid deterioration is caused by the selective consumption of tantalum oxide during cathodizing.⁶

In this paper, a recent progress on the development of a highly durable IrO₂-Ta₂O₅/Ti anode to the cathodizing-induced deterioration is presented. The effects of the structure of the catalytic layer on the lifetime for the electrolysis accompanied by periodic cathodizing are discussed.

The preparation procedure of IrO₂-Ta₂O₅/Ti electrodes is essentially the same as those described elsewhere,^{1,3,5,6} except thermal decomposition temperature. The IrO₂-Ta₂O₅ coating was formed on a pretreated titanium substrate by thermal decomposition of a precursor solution prepared by dissolving H₂IrCl₆ and TaCl₅ into n-butanol containing 6 vol% conc. HCl. The thermal decomposition was repeated until the desired amount of the coating layer was obtained. The nominal compositions of the coating layer were 70:30 of Ir:Ta mole ratio. The

obtained electrode was mounted in the PTFE holder, of which the exposed surface area was 1 cm². A platinum plate counter electrode and a sulfuric acid solution (pH=1.2) were used for continuous anodic and PR electrolyses. The electrolysis period in which the cell voltage increased 5 V more than the initial value during the anodic current being applied was termed the lifetime of the electrode. The characterization of the IrO₂-Ta₂O₅ coating before and after the electrolyses was carried out by XRD, XPS, XRF, EDX and FE-SEM.

A typical thermal decomposition temperature to prepare an IrO₂-Ta₂O₅ coating is *ca.* 773 K. In this case, the coating layer consists of IrO₂ crystallites dispersed in an amorphous Ta₂O₅ phase, which is selectively consumed by cathodizing. Therefore, we tried to modify the structure of the coating layer by changing the thermal decomposition temperature, and examined its effects on the lifetime for continuous anodic and PR electrolyses. Figure 1 shows the cell voltage transients during the PR electrolysis for the electrodes prepared with different thermal decomposition temperatures. The result indicates that the lifetime for the PR electrolysis is more prolonged at higher thermal decomposition temperatures up to 973 K. A comparison of XRD patterns for those electrodes revealed that the crystallization of tantalum oxide was enhanced and the predominant orientation plane of IrO₂ changed from (110) to (101), when the thermal decomposition temperature became higher. The effects of the thermal decomposition temperature on the morphology and composition of the coating layer, and the lifetime for continuous anodic electrolysis will be also shown.

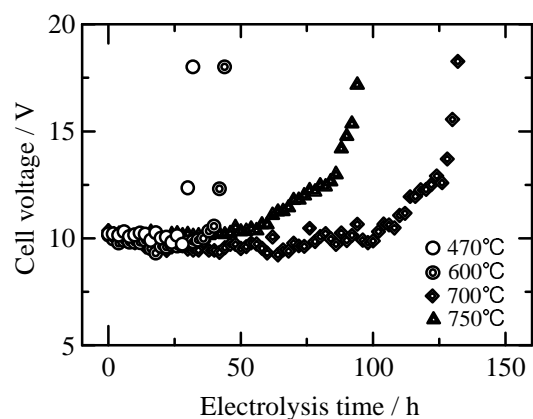


Fig. 1 Cell voltage transients of IrO₂-Ta₂O₅/Ti anodes prepared with different thermal decomposition temperatures during PR ($i_a=2\text{Acm}^{-2}$, $i_c=-0.1\text{Acm}^{-2}$, $t_a=t_c=300\text{s}$) electrolysis at 50°C.

References

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